Ontario Royal Commission on Transportation

Memorandum prepared by C. B. Breed to
accompany the printed report entitled -

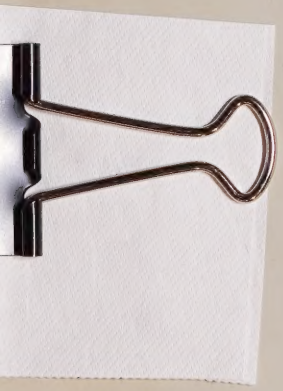
"R E P O R T

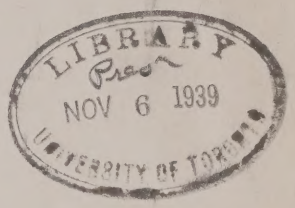
ON

A N N U A L H I G H W A Y

C O S T S

PROVINCE OF ONTARIO





Made to

The Railway Association of Canada

by

C. B. Breed, Clifford Older,

and

Wm. S. Downs."

April 20, 1938.

Ontario Royal Commission on Transportation

MEMORANDUM ACCOMPANYING
PRINTED REPORT ENTITLED

Report on Annual Highway Costs

Province of Ontario

made to

The Railway Association of Canada

by

C. B. Breed, Clifford Older
and Wm. S. Downs

February 21, 1938

Memorandum by C. B. Breed, April 20, 1938.

The intent of the following memorandum is to explain and amplify the printed report and to assist the reader in locating more readily the references referred to therein, a course which becomes necessary in consequence of the decision of the Commission not to hear such explanations and amplifications orally.

Comments are arranged in accordance with page numbers in the printed report (dated February 21, 1938).

C B Breed

April 20, 1938.

Preparation of the Report

Before preparing the report on the annual costs of Ontario highways, the authors personally examined during the months of September, October and November, 1937, about 2500 miles of road in the Province, including King's Highways, County roads, Township roads and City streets. A complete log was kept of the mileage covered giving a description of the types and conditions of all roads inspected. Certain gravel roads were sampled to obtain nature and depth of the surface material. Wherever new construction was in progress, the nature of the work was examined, and questions asked of the engineers and contractors as to the details of the work. On the inspection trips the composition and density of traffic was also observed. A map is submitted herewith showing the routes covered by the inspection trips.

A thorough study was also made of all available published reports pertaining to the cost and development of Ontario highways, such as Annual Reports of the Department of Highways, Public Accounts of the Province of Ontario, Highway Traffic Acts and Regulations, Annual Reports of Municipal Statistics, and Dominion Bureau of Statistics reports on the Highway and the Motor Vehicle. Statistics were assembled showing the amount of construction and maintenance expenditures on all classes of roads, rural and urban for the period 1890 and 1900 to date respectively. Statistical data supplied


INDEX OF CITIES, TOWNS AND VILLAGES
INDEX OF LAKES
PROVINCE OF QUEBEC
LAKE HURON
GEORGIAN BAY
LAKE ONTARIO
LAKE ERIE
TORONTO
HAMILTON
BUFFALO
KINGSTON
PETERBOROUGH
OTTAWA
KING'S HIGHWAY 17 ONT
LEGEND
INSPECTION TRIPS - Sept.26 - Nov. 4,1937
Roads inspected are indicated by black lines
Numbers beside black lines indicate dates on which trips were made.
ROAD MAP
OF THE SOUTHERN PORTION OF THE
PROVINCE OF ONTARIO
1937-38
HON. M. F. HEPBURN, PRIME MINISTER
J. HAMBLETON, DIRECTOR
TRAVEL AND PUBLICITY BUREAU
TORONTO - ONTARIO

by the Ontario Department of Highways in answer to the Commission's Questionnaire were given full consideration in the preparation of the report.

A study was likewise made of available reports dealing with problems similar to that of Ontario. Some of these reports have been published in Great Britain and others in the United States. The authors have been personally engaged in the preparation of some of these reports, and have had considerable previous experience in problems of this character, as well as in practical highway construction and maintenance.

The report is the result of about five months of intensive study. Several conferences of the three authors were held at which each important feature of the problem was thoroughly discussed from every angle. No effort was spared to obtain all information pertinent to the study, both in Canada and in the United States.

The Public Utility Approach to the Problem

In our report we have applied the public utility principle to the Ontario highway transport problem. This is the only sound and defensible method of approach to such a problem. The public utility characteristic of the highway transport system is accepted and its application advocated by leading students of highway economics.

In duscussing the need for a uniform system of highway accounts, Dean Marston, of Iowa State College, makes the following statement:

(16th Annual Proceedings, Highway Research Board, Washington, D.C., page 48)

"The author believes that the cause of the inadequacies and inconsistencies of our present highway accounts is mainly a fundamental error in our concept of the true status of highway systems. We have thought of them as merely special examples of general governmental activities, like legislative, executive, judicial, and police activities, all housed, maintained and rehoused by taxes levied on all rather than by charges to individuals for the actual services rendered to each. In contrast to this erroneous concept, our highways are simply great public utilities, comparable to publicly owned power and light plants, waterworks, and the like. So called highway 'taxes' and 'fees' are comparable to the bills against customers of power and light plants for the service rendered them individually. Highway revenue charges should be distributed among highway users in equitable proportion to services rendered. Highway accounting systems should provide all the accounting data needed to show true present actual (depreciated) values of highway property, and the true annual actual total costs of highway systems, including their true annual actual depreciations."

In the case of Brashear Freight Lines, Inc. vs. Missouri State Highway Commission (pages 103-4), Dean Marston makes the following statement which further amplifies his view:

"Since the state licenses of motor vehicles give them the right to travel over all the state's rural roads and urban streets, all the rural roads and the urban streets of each state together constitute the state's highway public utility. For each such state highway utility, equitable highway 'taxes' and fees (plus any miscellaneous highway receipts) are those which (in excess of diversions to other than highway purposes) will produce annual highway revenues equal to the total annual cost (including depreciation and interest) of the state's roads and streets.

"The annual cost of the roads and streets of a state is the sum of the following items:

1. The total annual road and street operating, collection, highway patrol, traffic control and miscellaneous expenditures.

2. The total annual road and street depreciation.

3. Fair interest cost charges on the depreciated cost-value of all existing road and street properly devoted to road and street service."

In discussing the allocation of highway taxes, Roy W. Crum, Director of the Highway Research Board, Washington, D.C., makes the following statement supporting the public utility principle:

(Civil Engineering, January 1938, p. 35)

"The concept of highways as public utilities is sound, and I believe that established principles of public utility management could well be applied to highway finance and administration."

The public utility principle applied to the highway transport problem requires that the cost of all highways be appraised regardless of political boundaries or administrative classifications, and that the annual cost of these facilities be charged against the users in the proportion to the benefits received.

The highway transport system is not unlike a great railroad system which, though it depends upon the main lines for most of its earnings, must nevertheless maintain terminals and feeders, not for the revenue which they alone produce but for the traffic which they contribute for the main lines.

The necessity for preserving the unity of the highway system in cost analysis is illustrated by an analogy drawn by J. A. Sourwine of the U. S. Bureau of Public Roads in discussion of the Report of Committee on Highway Transportation, 10th Proceedings, Highway Research Board, p. 363. Mr. Sourwine said,

"To select one arbitrary stretch of highway; to ignore all branch highways leading into that highway, and to ignore both the sources and destinations between which vehicles move, - seems comparable to the cutting off of a man's feet at his ankles, his hands at the wrists, and his head at the neck, and still count him as a living organism, and proceed to figure the operating efficiency of the parts remaining, which constitutes the portion normally connecting the feet with the hands, and both feet and hands with head. Under such an assumed condition, the working organism will be dead. There will be no use in figuring out a theoretical value for the parts remaining. The activity of the organism will have ceased and so will its value - and the value of each of its parts. We can not but see the analogy of an actively operating highway system to a human organism. The highway system also is a living organism. Its body, consisting of main traffic highways, is an important part of the system as a whole, - but to be a living, active, effective organism, it requires also hands and feet and head. The persons and material transported over it have in each case a source and a destination."

The views expressed above by these students of highway economic problems are unbiased and sound.

The motoring public evidences its belief in the public utility characteristic of highway systems in its insistance that revenues received from motor vehicles shall all be devoted to highway expenditures.

Certain commercial operators in Ontario are restricted by license to definite routes. These operators claim that they should pay only their share of the cost of these specific routes and nothing in addition for the support of the entire highway system.

The roads over which these commercial vehicles operate are the most heavily travelled roads and the "best paying" roads, because there are many vehicles (about 80% are passenger cars) contributing to their cost. If the commercial operators were required to contribute only their proportional share of these primary roads they would pay little indeed - but the very existence of these highways in a state of improvement suitable for commercial use is due to their function as primary arteries for the larger all-inclusive highway system. Even though they are restricted to specific routes, commercial vehicles are using facilities which were created as an integral part of the entire system, and therefore commercial users should contribute to the system as a whole just as much as any other user of the highways. Even though the routes of a few commercial vehicles are limited, yet all other roads of the province are potential truck and bus routes.

The success of the commercial operator's business likewise depends upon the existence of branch and feeder roads, even though he never travels upon them. The freight which he carries seldom originates or is distributed on the side line of his designated road. It must be collected over feeder roads and delivered over feeder roads. Similarly a bus line operating over a fixed route must rely upon patronage originating some distance from its stated route. Much of this patronage will arrive at the bus terminal by other transportation means using feeder roads and will require supplementary transportation to reach their ultimate destination.

A very large proportion of all vehicles are free to travel where they will over the ribbons of highways which extend in all directions to all parts of the Province. Some of these highways are primary roads, main highways; others are secondary roads, others are city streets; all depend upon one another for their full utilization. A trunk highway would carry little traffic and would fail to justify its trunkline aspects if it did not possess feeder roads and terminals to produce and receive the traffic. The cities with all their streets are the great terminals as well as feeders for the trunk highways. Likewise the township roads serve to produce traffic which makes its mileage primarily on the main roads. Hence, the value of a township road or city street to the great highway

system cannot be measured entirely by the volume of traffic which that road or street carries. It must be considered from the effect of the traffic which it produces for the system as a whole.

In appraising the cost of the highway system the artificial boundaries created for administrative purposes have no significance; the boundaries are constantly changing.

Recognizing the importance of feeder roads, several of the States have recently taken large mileages of local roads into the State Highway System and improved them. Other States, although not absorbing these roads into the State Highway System, have allocated large portions of motor vehicle revenue to their improvement. The same trend is evident in Ontario, since the Province has progressively increased its aid to municipalities for county and township roads. In 1936 the Department of Highways took over all roads in the Northern Development and is proceeding to bring these roads up to the same standards used in Southern Ontario.

In applying the public utility principle to the Ontario problem, we have drawn no distinction between users because of their use or any special restrictions imposed upon them. We have allocated the annual cost of the highway system to the different types of vehicles solely on the basis of cost of facilities required and use made of the facilities.

The public utility principle implies a business or commercial use of the highways by all classes of vehicles including passenger cars as well as trucks and busses. As time goes on, highway travel takes on more and more of a business character. For a few months in the summer a certain amount of Sunday travel is so-called "pleasure driving", but most of the traffic, day in and day out, is purposeful, that is, it has a definite destination for a definite purpose. No matter what motive lies behind the travel, the user derives a benefit from the highway for which he should pay a charge, just as much as he should pay, and does pay, a charge for switching on an electric light in his home.

Commercial users are prone to shift their responsibility for highway costs on to the shoulders of the general public with the argument that the general public benefits from the type of service which they render and should absorb much of the annual road cost in general taxation. This is equivalent to making everyone share in the cost of water or light or gas or the telephone, whether they employ such facilities or not. All of these utilities have brought wide spread benefits to the public as a whole, but the cost is borne, and properly, by those immediately participating in the benefits. In these latter utilities, there is usually a minimum charge representing cost of facilities required (sometimes called "stand-by" charge) and in addition there is a charge dependent upon the measured quantity used. The same principle applied to highway transport

requires that the users pay their full cost for required highway facilities and for use made of them. The passenger car users comprise a large percentage of the general public. They should pay directly for highways through motor taxes rather than indirectly through property and income taxes. Commercial users will pass their charges on to those immediately benefited, the shippers, and thence the costs will be distributed to those consuming the goods. All highway costs must ultimately be paid by the public - there is no miraculous source of public funds. The public utilities principle obtains these funds, however, through the medium of those directly benefited, namely, the motor vehicle users

Page 1 of Printed Report

There are tabulated hereunder 14 of the more comprehensive reports on this general subject.

The purpose of this list is to indicate the particular reports which we have carefully studied with respect to the Ontario problem, and to point out where the objectives of these different reports are different from the objective of the Ontario study and to emphasize their scope and limitations.

Page 1 of Printed Report (Cont'd)

(1) Report of the Conference on Rail and Road Transport.

Great Britain, July 29, 1932

(Salter Conference Report)

The general object was to establish a "fair basis of competition" and a better "division of function" between rail and road transport. All sides of the problem were to be considered impartially. Submissions were not solicited, but those filed by interested parties were reviewed and considered.

The Conference considered the following phases of the probkem:

(a) incidence of highway costs in relation to contributions of different classes of motor vehicles

(b) nature and extent of regulation that should be applied to freight transport by rail and road

(c) any measures which might improve competitive conditions between road and rail transport to the advantage of trade and industry.

The objective in item (a) was similar to that of our Ontario report. The conclusions reached by the Salter Conference, however, were a result of "give-and-take" between highway users and railroad representatives, and are therefore in the nature of a compromise rather than the result of analysis.

Page 1 of Printed Report (Cont'd)

(2) Report of Highway Cost Commission, State of Washington

(a) First Report - January 1935

The Commission was created by a Legislative Act which "declared that the apportionment of special taxes among motor vehicles of various types should be based upon use of facilities required, and should be sufficient to pay their fair share of the annual costs of highways, including administration, maintenance and construction". The Commission was to ascertain and report to the legislature the necessary facts and to recommend legislation.

The "fair share" of the annual cost of highways to be met by special motor vehicle taxes was arbitrarily taken as the average annual budget for recent years of the State of Washington Department of Highways. Only to the extent that the State Highway Department contributed to secondary roads and city streets was their cost included. No attempt was made to compute the annual cost since the annual expense only was considered.

The conclusions reached with respect to highway facilities suitable for basic vehicles and for heavier vehicles were based largely upon opinions expressed in a questionnaire sent to highway engineers, trucking concerns, automobile clubs, and many other organizations or persons throughout the United States who were interested in highways or in motor transport.

Page 1 of Printed Report (cont'd)

This Commission did not in any sense make an analytical study of the problem of highway costs. They attempted to develop advice to the Legislature which would not be so radical as to be likely to fail of passage. The Commission frankly states that they gave consideration to the ability of the existing motor transport to pay and gave consideration to the social service it rendered and do not intimate that at any stage of their deliberations did they consider whether or not it was economically sound from the public standpoint to subsidize the heavier commercial vehicles.

This Commission started with the answer and worked backward. They really started with only part of the answer because they never attempted to find the annual cost of highways, but merely used the recent State Highway budget for highway expenditures and then redistributed the charges to different classes of vehicles in such a manner as to produce this highway expenditure.

(b) Supplementary Report - January 1937

The 1935 report dealt specifically with the apportionment of the existing yearly state budget for highway expenditure on the basis of "facilities required"; the 1937 (supplementary report) shifts the emphasis to the "services rendered" to motor vehicles through the public highway.

This second report reached the conclusion that the ton-mile is the best measure of highway service. The schedule of charges against individual vehicles in each weight class was adjusted slightly in the light of more accurate mileage and weight statistics.

Page 1 of Printed Report (cont'd)

(3) Report of the Interim Committee, State of Oregon, regarding The Fees and Taxes Paid by the Road Users for the Highway Facilities Provided, January 1, 1937.

This committee was appointed by the Governor of Oregon for the purpose of studying the entire question of the use of the highways of Oregon by motor trucks for hire, with particular reference to the regulation of highway transport and the adequacy of present fees to properly compensate the state for the "wear and tear" caused by motor truck transportation.

The report deals only with the primary and secondary state highway costs and is therefore only a partial analysis of the Oregon Highway Problem. The authors do not consider the report as final, but subject to change and amplification when the results of the Oregon State-Wide Planning Survey becomes available.

Page 1 of Printed Report (cont'd)

(4) Motor Vehicle Taxation in New Jersey, by W.D. Ennis
January 1935.

This report was made for the New Jersey Taxpayers' Association at the request of the Associated Railroads of New Jersey. The purpose of the report was to investigate present taxes on heavy vehicles in New Jersey and to make recommendations for greater equity in motor vehicle taxes.

The report is a rather complete example of cost analysis and allocation for a particular state. New Jersey differs greatly from Ontario because it has fewer miles of highway but many more motor vehicles, particularly heavy vehicles. Since there are more vehicles to share the cost in New Jersey, we may expect a lower charge per vehicle in that state than in Ontario.

Page 1 of Printed Report (Cont'd)

(5) Motor Vehicle Taxation in New York, by W. S. Downs, September 15, 1935.

This report was prepared for the Associated Railroads of New York. It is not available for general distribution.

The purpose of the study was "to determine the cost of the highways and streets in the State of New York, and from the data that are available to make a fair and equitable allocation of the cost between the general public and the highway users in proportion to the costs for which they are peculiarly responsible. It involves a further allocation of the cost between the different classes of vehicles."

The analysis holds very close to the basic highway idea agreed upon by the Joint Committee of the Railroads and Highway Users, 1935. (See Item 11 of these notes.) The data used in the analysis are complete and well supported.

The results are applicable to the State of New York, which has a much greater density of traffic particularly around New York City.

Page 1 of Printed Report (Cont'd)

(6) Government Aid to Highway Transportation, October 1936

A study made by the American Association of Railroads

This report has not been released for publication. Its purpose was to determine the amount of subsidy enjoyed by highway users throughout the United States for the period 1921-32, and also to determine the proper allocation of motor vehicle special taxes among different classes of vehicles for the country as a whole.

This report was prepared as a parallel to a similar report undertaken by the Staff of the Federal Coordinator of Transportation which has not yet been published. The scope and procedure of this report is influenced by that adopted by the Coordinator's Staff. While it may be feasible to study such a problem on a national scale, its specific application should be made to limited districts only, such as to each state which usually has its own particular highway problem. The report for the American Association of Railroads represents something of a compromise between the views of the railroad representatives and the Coordinator's Staff. It is weak in that it attempts to apply average values to all parts of the United States.

Page 1 of Printed Report (Cont'd)

(7) Study of Missouri Highway and Street Costs Chargeable to Motor Vehicles ..... prepared by the Missouri State Highway Commission in the case of Brashear Freight Lines, Inc., et al., Plaintiffs, vs. Public Service Commission and State Highway Commission of Missouri. Published January 1938.

"The Plaintiffs contend, among other things, that fees and licenses bear no reasonable relation to the use, and the extent of the use, of the highways in the State of Missouri; that the fees collected are excessive, and grossly excessive, and constitute an unreasonable burden on interstate commerce and the operation of the Plaintiffs engaged therein."

"The purpose of this cost study was to determine (1) the annual highway costs properly chargeable to motor vehicles, and whether revenues from all motor vehicle sources are sufficient to care for these costs; (2) whether heavy trucks have been responsible for increased construction or maintenance costs over the costs which would be necessary if only lighter vehicles were operated over the highways; and (3) whether the motor vehicle collections made by the State or its agencies from certain types and classes of vehicles operating on Missouri highways are equitable."

Since the purpose of the trial was merely to determine whether or not the present fees charged against commercial vehicles were excessive rather than to determine precisely what the proper charges should be, the authors adopted a most liberal

Page 1 of Printed Report (Cont'd)

point of view towards the motor vehicles as indicated by the following quotation from their report:

"Since the final figures indicate that, even under the most liberal treatment of this particular problem, the prevailing fees are, to say the least, reasonable, all doubts have been resolved in favor of the motor vehicle, maximum charges have been calculated as benefits to property for social and community service and minimum assessments have been made against motor vehicles as a class as charges for special benefits."

(8) A Study of Highway Costs and Motor Vehicle Taxation in Illinois, by V. L. Glover, Engineer of Materials, Illinois Division of Highways.

This report (not yet published) is similar in purpose to the Missouri Report, and nearly identical in form. The conclusions reached are substantially the same; namely, that on the most liberal basis, motor vehicle taxes, particularly those on the heavier vehicles, do not equal their fair share of highway costs.

Page 1 of Printed Report (Cont'd)

(9) The Cost of Providing Highways Suitable for Various Classes of Vehicles, by W. S. Downs, September 20, 1933.

This report contains the answers to certain questions presented to Mr. Downs by the Associated Railroads of Pennsylvania. The questions pertained to the width, thickness and cost of pavements required for heavy vehicles compared with those required for basic vehicles (passenger cars and light trucks). The report was necessarily limited to the questions propounded. It was a preliminary step to the larger problem of determining how much of the responsibility for highway costs rests with the heavier vehicles and how it should be allocated.

(10) Report Upon Cost of Roads Required for Heavy Motor Vehicles Compared with Cost of Roads Adequate for Passenger Automobiles and Light Trucks, by C. B. Breed, November 1, 1933.

This report contains the answers prepared by Mr. Breed to questions presented to him by the Associated Railroads of Pennsylvania. These were the same questions asked of Mr. Downs (see above). Mr. Breed's answers were in substantial agreement with those of Mr. Downs. Both reports (9) and (10) were prepared independently and related to the entire United States.

Page 1 of Printed Report (Cont'd)

(11) Regulation and Taxation of Highway Transport,

Recommendations of Joint Committee of Railroads and Highway Users, January 30, 1933.

This committee was made up of the presidents of the larger railroads and of large motor vehicle manufacturing and operating companies.

This is an important report. It represents the nearest approach to an agreement between the railroads and highway users that has been reached before or since. It sets forth basic principles of taxation which have been widely applied to problems similar to the Ontario highway cost and allocation study.

(12) Report of the Royal Commission to Inquire into Railways and Transportation in Canada, 1931-32 (Duff Report)

This report deals principally with the plight of the Railroads.

There is only brief reference to the taxation of motor vehicles. Certain opinions are expressed as to the allocation of road costs. The report presents no data supporting their opinions. They have not attempted a detailed analysis to support them.

Page 1 of Printed Report (Cont'd)

(13) The Ton-Mileage Basis for Allocating Motor Vehicle Charges, by Professor R. A. Moyer, Iowa State College. Presented to the Department of Highway Transportation Economics, Highway Research Board, Washington, D.C., December 4, 1935.

This report is a study of the taxation of motor vehicles in the United States in general and in Iowa in particular; it deals primarily with the allocation of highway charges in Iowa.

A schedule of highway charges was prepared which included a charge for registration, gasoline and a ton-mile charge, the aggregate of which comprised the entire charge. The amount of these charges was not based upon a highway cost analysis; the present taxes paid by passenger cars were arbitrarily assumed at the bottom of the scale and the present charges for common carrier heaviest trucks were assumed at the top of the scale. The proposed charges merely "smoothed out" present rates and resulted in materially raising charges against some in the intermediate truck classification.

He concluded that it was necessary to correct the inequities of the present charges which are based upon registration fees and fuel taxes by adding a third element which was based upon a graduated ton-mile charge for the use of the road.

Page 1 of Printed Report (Cont'd)

(14) A Study of Motor Vehicle Taxation in Pennsylvania, U. S. Bureau of Public Roads, 1932.

This was a series of exhibits depicting graphically the allocation of highway costs among motor vehicles, using Pennsylvania costs for illustration purposes. The bases for this analysis were unsound. The display has been removed from circulation. The principal fallacies of this analysis were (1) all motor vehicle revenue was applied to the state highway system only, thereby ignoring thousands of miles of secondary roads and city streets, (2) the allocation among vehicles was made on arbitrary assumptions as to the thickness of concrete pavement required for different classes of vehicles, neglecting all other types of pavements and many other important factors that enter the problem.

Page 8 of Printed Report

Middle of page, paragraph headed (1)

Percentage Distribution of Annual Cost

for Typical Year - 1936

	Rural Roads	Urban Streets	Both
Interest on Unamortized Capital Expenditure	31.3%	31.9%	31.5%
Amortization	38.0	42.0	39.1
Taxes	6.9	7.1	6.9
Maintenance			
Administration	3.3%	.2%	2.4%
Maintenance	20.5	18.8	20.1
	100.0%	100.0%	100.0%

The above combined gives

Annual Cost pertaining to Capital investment (Taxes are on unamortized investment)	77%
Maintenance	20%
Administration	3%
	100%

Page 5 of Printed Report

The Salter Conference reached the following conclusions:

On page 16 of their report the Conference concluded that "legacy from the past" and "community use" (social -necessity) cancel each other, and that the total contributions from motor vehicles, licenses and gas tax, should equal current expenditure on roads, "without net addition or reduction in respect of the two above items".

The Conference allocated highway costs first on a gasoline consumption basis and then on a ton-mile basis and took the mean as their final allocation. In the ton-mile method they assigned 1 1/2 million pounds of the total highway cost exclusively to vehicles over 4 tons unladen in payment for their special facilities, and then allocated the remainder to all vehicles.

£ 60,000,000 was to be collected in all
£ 36,000,000 from passenger cars, hackneys and motor cycles, etc.
£ 24,000,000 from commercial goods vehicles.

It was recommended that heavy trucks within cities should receive a 25% refund from the fees derived from the above allocation on account of their lower mileage, and limited use of highways from wharves to factories.

Page 7 of Printed Report

The expenditure amounts used throughout this report in diagrams and tables are based upon statistics compiled by the Bureau of Economics, Canadian National Railways, on file with the Commission and entitled

(a) Statistics of Expenditures on Highways of Ontario 1889-1936 - January 3, 1938.

(b) Statistics of Expenditures on Streets 1900-1936 - November 12, 1937.

The authorities for these were municipal and provincial records and the following reports;

Annual Reports of Ontario Highway Department

Public Accounts of Ontario

Municipal Statistics

The Highway and the Motor Vehicle in Canada (Dominion Bureau of Statistics)

(Last Paragraph, Page 7 of Printed Report)

The annual per capita expenditure on rural roads in the United States for the period 1890 to about 1910 ranged from 50¢ to $1, which is in the same range as the per capita cost of the rural roads in Ontario for the same period.

Page 20 of Printed Report

A pertinent discussion of taxes on highway property will be found on pp. 28-32 of the Missouri Report, No. 665 In Equity District Court of United States, Brashear Freight Lines, Inc. vs. Public Service Commission of State of Missouri.

Page 24 of Printed Report

The annual cost of all city streets, exclusive of lighting and sidewalks, has been included because they constitute an important part of the highway system; they feed traffic to the main arteries of travel without which these arteries would be little used. The public utility concept requires consideration of streets as well as rural roads. The highway revenue derived from urban streets is a very large proportion of the total highway revenue, although up until now the cities have not received benefit from this revenue for street expenditures.

In the New Jersey Report 51% of the cost of city streets were charged against the motor vehicle; in the New York Report 48%; in the A.A.R. Report 53%; in the Missouri Report 50%; in the Illinois Report 50%; and in the State of Washington Report 8%. (This low percentage was not the result of an analysis of the requirements of the city streets, but represents what the State Highway Department had spent the previous year on highways within city limits.)

Page 24 of Printed Report (Continued)

That there should be a division of cost between motor vehicles and general taxes was reached on the theory that a proportion of the use of city streets is local in character and has no relation to the travel on the main arteries going through the cities. The actual percentage adopted was usually arbitrarily determined by using the ratio between the cost per capita of urban streets before the advent of the motor vehicle and after; this assumes that all costs before the motor vehicle came were for local traffic. In our report we hold that before the motor vehicle came there was a very considerable use of the city streets for commercial purposes. But since we have charged none of the costs of city streets prior to 1919, there seems to us to be no reason for excluding any of the cost of city streets since 1918 from the total costs to be distributed except the cost of facilities for pedestrians, such as sidewalks and street lighting.

Page 28 of Printed Report

Estimate of Motor Vehicle Revenue 1937-45 Based upon 4% increase in Registration per Year. In the following table the year 1936 means the year ending March 31, 1937 and so on.

1936	$ 26,810,000	
1937	27,870,000	
1938	25,480,000	28,980,000 (1938 without deduction) - 3,500,000 Deduction on account of reduction in fees 25,480,000
1939	26,500,000	
1940	27,560,000	
1941	28,660,000	
1942	29,800,000	
1943	30,990,000	
1944	32,230,000	
1945	33,520,000	

Drop in revenue of 1938 due to $5 flat reduction in all passenger car rates and 25% reduction in fees for all commercial vehicles. See Ontario Highway Department answer to Question 41 for fees in former years.

The assumed increase in registration, 4% per year, is based upon the fact that in 1934 Ontario registration increased 4.2%, in 1935 4.1%, in 1936 4.6%, as shown on page 21 of "Canadian Facts and Figures for 1937".

Ontario Highway Department Revenues from Motor Vehicles
(Accompanying Page 28 of Printed Report)

Year Ending	Motor Licenses	Gasoline Tax	Gasoline Pumps, etc.	Interest	Misc.	Total
Oct. 31, 1904	1,282					1,282
1905	3,096					3,096
1906	5,523					5,523
1907	8,098					8,098
1908	10,008					10,008
1909	12,419					12,419
1910	24,394					24,394
1911	50,831					50,831
1912	73,256					73,256
1913	105,559					105,559
1914	149,210					149,210
1915	334,760					334,760
1916	639,987					639,987
1917	930,753					930,753
1918	1,214,094					1,214,094
1919	1,580,147					1,580,147
1920	1,990,833					1,990,833
1921	2,945,360				365,000	3,310,360
1922	3,477,430					3,477,430
1923	4,296,009					4,296,009
1924	4,785,235		1,864		260,409	5,047,508
1925	5,638,993	1,974,434	5,496		698,040	8,316,963
1926	6,415,714	3,376,091	6,202	3,809	389,582	10,191,398
1927	5,964,864	4,032,942	12,154	14,953	436,145	10,461,058
1928	6,470,152	4,607,380	18,487	25,105	263,959	11,385,083
1929	7,848,449	8,497,594	19,682	26,516	352,064	16,744,305
1930	5,547,255	10,756,836	27,224	37,093	394,363	16,762,771
1931	5,610,443	10,950,645	29,203	25,120	451,407	17,066,818
1932	7,376,674	12,341,238	50,505	59,567	196,038	20,024,022
1933	7,421,160	12,620,057	63,425	37,920	156,207	20,307,769
1934	8,049,714	12,961,344	61,737	19,475	105,289	21,197,559
(5mos.) 1935	6,136,807	4,789,719	35,208	4,609	361,507	11,328,850
Mar.31, 1936	9,144,265	15,021,994	67,687	49,885	30,190	24,314,021
Mar.31, 1937	10,916,491	15,764,158	86,445	31,864	11,302	26,810,350
	115,181,265	117,703,432	485,319	335,916	4,471,592	238,177,524

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Beyond 1936 Fig. 7 is merely a prediction. All allocations made in this report relate to the annual cost as of 1936, so that whatever our predictions may be for the years beyond 1936 will not affect the results of this report.

In Fig. 7 it will be noticed that revenue and cost lines diverge; the revenue curve is plotted on the basis of 4% increase in registrations per year. Similarly the cost curve is based upon 4% increase in capital and maintenance expenditures per year. One of the reasons for the divergence of these two lines lies in the fact that the capital expenditure in roads purchased 15 to 25 years ago is less than now, we are charging out 1/25 of a less capital expenditure each year, while we are at the same time adding 1/25 of a greater expenditure which makes the cost line climb at a steeper rate than the revenue line. If in the future it is actually found that such a divergence as here represented occurs, then there will probably have to be another upward adjustment of motor vehicle charges.

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The amount, $14,100,000, is the average annual cost of $326,000,000 Serial Bonds bearing 4.55%, or it is the average annual cost of $326,000,000 Sinking Fund Bonds bearing 3.58%.

This yearly contribution of $14,100,000 has been allocated to the public. It will be noticed that this is about equal to the total annual costs of all city streets as shown in Table II, p. 25, for 1936. During the depression year 1934, less than $5,000,000 was expended for construction and maintenance of city streets as shown in Fig. 3, p. 15.

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The life and salvage value of pavements which have been suggested in other recent reports are as follows:

	Life	Salvage
New Jersey Report (Pavements only)		
Concrete pavements	20 years	None
Bit. Concrete on stone base	15 "	"
Bit. Macadam on gravel	12 "	"
(These service lives were used for amortizing capital, but the statement is made that they are only about 80% of the actual expected service lives.)		
New York Report		
Composite rural road	24 years	None
" city street	27 "	"
A.A.R. Report		
State Highways	29 "	3.1%
County and Local Roads	33.4 "	6.9%
City Streets	29 "	3.1%
Missouri Report		
State Highways	34.25 years	None
County and Local Roads	25 "	"
City Streets	25 "	"
Illinois Report		
State Highways	29.7 years	None
County and Local Roads	21.4 "	"
City Streets	27.5 "	"

Notice the trend to allow no salvage value.

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The following diagram represents the thickness of concrete pavements obtained by the three usually recognized formulas:- Older, Sheets and Westergaard. If the thickness of pavement required for 4000 lb. wheel load is read for any of these curves and them multiplied by the $\sqrt{3}$, it will be found that the thickness read from the same curve at the 12000 lb. wheel load is $\sqrt{3} = 1.7$ times the reading at the 4000 lb. wheel load. For example, in the lowest curve the thickness is 3.9" at 4000 lb. wheel load 1.7 x 3.9" = 6.7". It will be noticed that this same curve reads 7.1" at the 12000 lb. wheel load. Similarly, if the next to the top curve is used the reading at 4000 lbs. is 5.6", and 1.7 x 5.6" = 9.5"; the reading on the diagram at 12000 lb. wheel load is 9.8". All of these formulas then indicate that the thickness of the pavement is at least proportional to the square root of the wheel load. An examination of this diagram shows that whether the wheel load is considered to be at the corner of a pavement slab, along its edge or in the middle of the slab,- generally speaking, the same law holds.

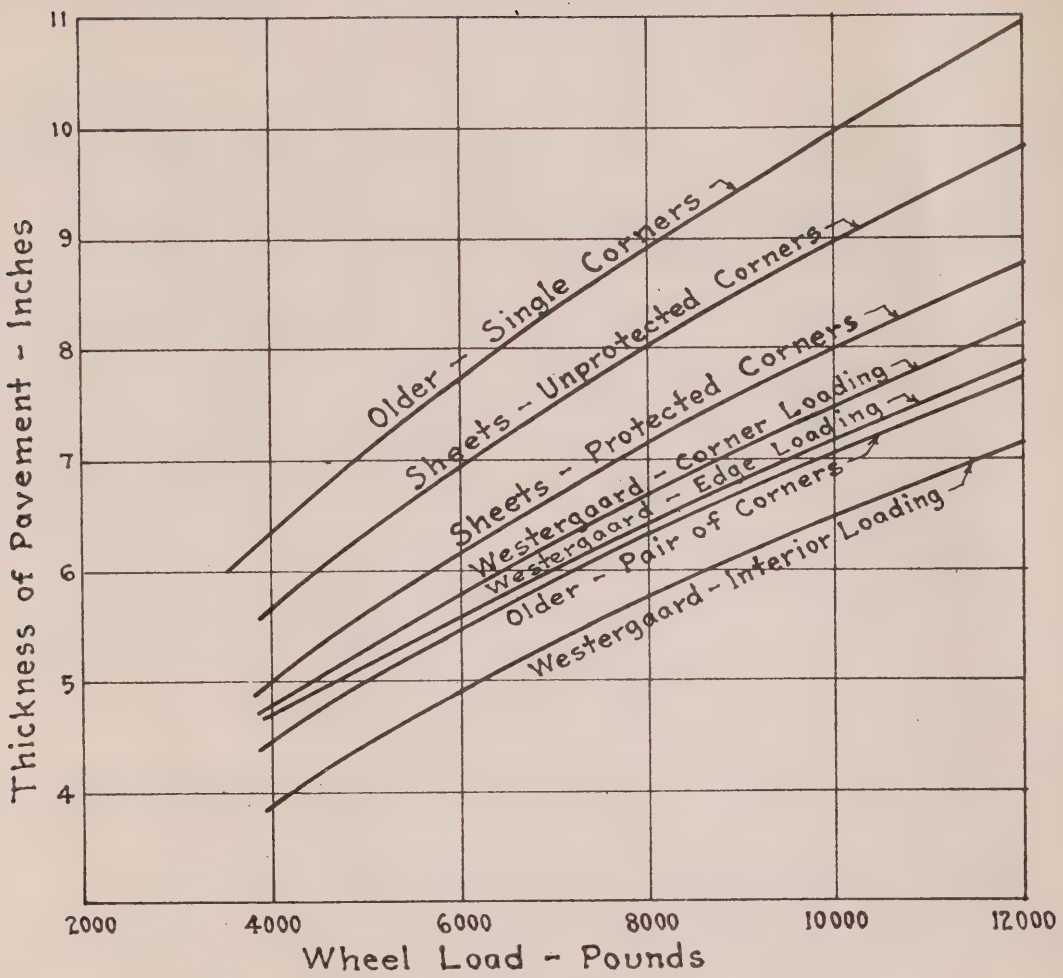

FIG. 90

Explanatory Notes:

All curves are plotted for a flexural working stress of 300 lbs. per sq. in. All formulas assume a relatively soft subgrade, equivalent to k = 100 in the Westergaard Method.

Older Formula for single corners $d = \sqrt{\frac{3W}{f}}$ Where d is thickness in in., W is wheel load in pounds, and f is flexural stress in lbs. per sq. in.

" " " pair of " $d = \sqrt{\frac{3W}{2f}}$

Westergaard Method

Wheel Loads (lbs.)	4000	6000	8000	10000	12000
Radius used for Corner Loading	4.27"	4.87"	5.48"	5.96"	6.33"
" " " Interior "	4.27	4.87	5.48	5.96	6.33
" " " Edge "	6.03	6.89	7.76	8.41	8.95

Sheets Formulas for unprotected corners $d = \sqrt{\frac{2.4W}{f}}$

" " " protected " $d = \sqrt{\frac{1.92W}{f}}$

Where d = equivalent uniform thickness (in.), W = wheel load plus impact (lbs.) on pneumatic tires, and f = flexural stress (lbs./sq.in.).

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This is one of a series of three reports describing tests on concrete pavements made by the U.S. Bureau of Public Roads at their experiment station in Arlington, Virginia. The first of the series described the test conditions and apparatus used; it is published in "Public Roads", October 1935. The second of the series describes warping stresses in concrete slabs, "Public Roads", November 1935. The third article describes tests made on typical joint designs for concrete pavements, "Public Roads", December 1935.

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Fatigue of concrete - See Bates Road Tests, Bulletin No.21, Illinois State Highway Department, January 1924, p.22 for experimental determination of the effect of fatigue.

For application of fatigue to estimating the age of a pavement before the first cracks appear, see Sheets, Portland Cement Association Publication "Concrete Road Design", p. 56.

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From page 238, 14th Proceedings Highway Research Board, it will be seen that a tire having a size 7.00-20 for a wheel load of 1900 lbs. and carrying an inflation of 55 lb. per sq. in. will have a contact area of 33.8 sq. in.

The contact area for the 7500 lb. wheel load was obtained by interpolation from Table V, p. 241 of the same publication.

Page 67 Cost of Different Types of Pavement

The following costs were given by the Ontario Department of Highways in answer to Question 4 of the Questionnaire submitted to them.

	Per Mile
Concrete pavement 10-7-10" 6" gravel base	$ 23,000
Macadam (Penetration) 5" base plus 3" top	14,000
Mulch 2" to 4"	2500-5200
Retread 2" to 4"	3000-5800
Surface Treatment	400-1200

(1930-1937 costs)

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The Oregon Interim Report shows cost ratios on pp. 63 and 64 as follows:

A 22-ft. concrete pavement adequate for truck costs 77% more than an 18-ft. concrete pavement suitable for basic vehicles.

A bituminous macadam road for trucks costs 87% more than for basic vehicles.

Basic vehicles are defined on p. 36. They have a gross weight of 4000 lbs.

- - - - - - - -

See New Jersey Report (Ennis) pp. 96 and 97 for cost ratios between basic and standard highways. Heavy duty roads cost from 60% to 120% more than basic road.

Page 68. Additional Width

The increasing tendency toward greater size of motor trucks led the New York Port Authority to make the Lincoln Tunnel roadway 21'-6" wide instead of 20' used in the Holland Tunnel. This increased the tunnel diameter and greatly increased the cost.

See Engineering News-Record, November 18, 1937.
Civil Engineering, August 1937.

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On pages 92-93, 13th Proceedings Highway Research Board, paper entitled "Analysis of Road Costs on the State Highways of Worcester County, Massachusetts", the following percentages of capital cost for concrete and bituminous pavements attributable to the elements of construction in Massachusetts are given:

	Concrete	Bituminous
Grading	20%	35%
Drainage & Structures	10%	11%
Pavement and its Foundation	70%	54%
	100%	100%

United States Bureau of Public Roads determined the weighted national average in "Public Roads", July 1933, as follows:

Excavation	36%
Structures	15%
Pavement	49%
	100%

This is for the period 1925-29.

In Ontario excavation is a low percentage because there is no mountainous district, structures are low percentage because practically the only bridges are culverts and bridges of small span, - there are no large rivers crossing Ontario. Consequently the pavement cost is a large percentage of the total cost of highways in this Province.

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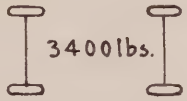
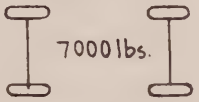
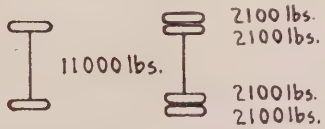
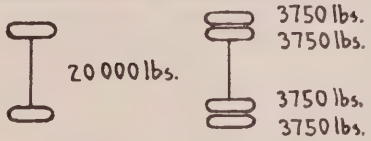
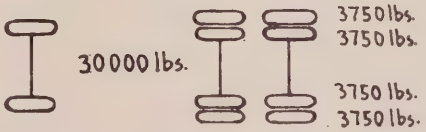
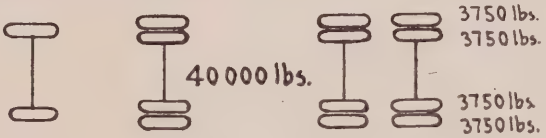
Maintenance increases with number of tires. If one passenger car passes along the road and thereby creates a maintenance cost, two passenger cars should cost double the amount that one does. It will be seen by examining the attached diagram that as the motor vehicles increase in weight they also increase in number of tires, so that the heaviest vehicles have four times as many tires as a passenger car, and the weight on each tire on some of these heavier vehicles is as great as the weight on all four tires of the passenger car. It would seem without further demonstration that the passage of these 16 or 18 tires that are on the heavy truck would do at least twice as much damage as the passage of 4 tires on the average passenger car.

The grinding of the surface of gravel roads and shearing off of the upper layer is the action which requires maintenance. Considering the heavy load on each individual tire of a truck and the bearing area of each tire, which is much greater than that for the passenger car tire, the amount of surface material that will be removed by the truck obviously is several times greater than that removed by the passenger car.

Maintenance costs are not kept in such a form as to make it possible to separate the maintenance due to trucks from that due to passenger cars.

The following information on effect of heavy vehicles is given in "An Economic Survey of a Section of Oregon Coast Highway", Oregon State Highway Commission, Table II, p. 6a:

Number of Tires and Tire Loads for Different Classes of Vehicles Compared with Highway Cost Index used in Table III

	Gross Weight / Probable Max. Tire Load		Ratio of Number of Tires	Highway Cost Index Table III
4 Tires	 3400 lbs. 875 lbs. 875 lbs.	Class I Passenger Car	4 Tires equals 1.00	1.00
4 Tires	 7000 lbs. 2600 lbs. 2600 lbs.	Class III Light Delivery Truck ($\frac{3}{4}$-1 Ton Capacity)	1.00	1.15
6 Tires	 11000 lbs. 2100 lbs. 2100 lbs. 2100 lbs. 2100 lbs.	Class V 1½ Ton Capacity Truck	1.50	1.44
6 Tires	 15000 lbs. 2800 lbs. 2800 lbs. 2800 lbs. 2800 lbs.	Class VII 3-Ton Capacity Truck	1.50	1.68
6 Tires	 20000 lbs. 3750 lbs. 3750 lbs. 3750 lbs. 3750 lbs.	Class X 4-Wheel Truck (5-Ton Capacity)	1.50	1.93
10 Tires	 30000 lbs. 3750 lbs. 3750 lbs. 3750 lbs. 3750 lbs.	6-Wheel Truck	2.50	1.93
14 Tires	 40000 lbs. 3750 lbs. 3750 lbs. 3750 lbs. 3750 lbs.	Tractor and Semi-trailer 8-Wheels	3.50	1.93
18 Tires		Truck and Trailer Combination Seen in Ontario 10 Wheels - 18 Tires Gross Weight 50000 lbs. Approx.	4.50	1.93

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(1) Heavy logging traffic on a road adequately designed for such traffic required about 110% more maintenance expenditure than on a road of similar type with normal mixed traffic.

(2) Heavy logging traffic on a road inadequate for such traffic required a maintenance expenditure of about 240% more than required on a road of similar type with normal mixed traffic (i.e., without the logging trucks).

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Gasoline Consumed by Foreign Cars.

This was estimated in two ways:

(1) By examining entry and exit statistics.

(2) By analyzing Ontario Traffic Counts.

(1) Entry Statistics are given on pp. 46-37 of "Canadian Facts and Figures". (These are also in Dominion Bureau of Statistics Report "The Highway and the Motor Vehicle" for 1936).

In 1936 about 2,000,000 cars entered Ontario for not over 24 hours - these are assumed not to have bought any gasoline in Ontario; 697,000 cars entered for up to 60 days, and 852 for more than 60 days. In the same year 265,000 Ontario cars were "exported for tourist purposes". We cancelled these Ontario cars against a corresponding number of foreign cars leaving (697,000 plus 852 minus 265,000) = 433,000 foreign cars that probably bought gasoline in Ontario, and for which there were no corresponding Ontario cars to buy gasoline in the States.

We first assumed that these 433,000 cars drove 500 miles in Ontario and made 18 miles to a gallon; they would use $\frac{500}{18}$ x 433,000 = 12,000,000 Imperial gallons. But in Tables IV and V we have allowed 13,399,000 gallons, which is equivalent to 550 miles per car. This odd amount resulted from including in this item the residue after "round numbers" had been used for mileages and rates of consumption in the several vehicle classes.

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(2) Traffic counts have been taken in Summer, Fall and Winter 1932-33. These are published in the Annual Report of the Highway Department for 1932. In these counts, foreign cars are separated from Ontario cars.

Weighting these counts for the different seasons and including counts at all available counting stations throughout the Province, we obtained for King's Highways a weighted annual average of 13.6% foreign cars to all passenger cars. This covers all seasons and all stations, some near the border and some inland, all in Southern Ontario, however, because records for this general district are the only ones published.

The Highway Report for 1932 also included counts on County Roads. These were not summarized in the report so as to give a general average, so we took 21 representative counties and developed a weighted average for all seasons and all counting stations and found that 6.4% of all passenger car traffic counted on County Roads was foreign cars.

Combining King's Highways and County Roads on the basis of average density of travel, we found a weighted average of 12% foreign cars to all passenger cars. Many of these foreign cars counted at border stations did not buy Ontario gasoline, so we should make a reduction in this percentage before applying it to the gross gasoline consumption for the Province. If 3/4 of these cars used Ontario gasoline, then the percentage of total gasoline used by foreign cars would be 9%.

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Tables IV and V show that total gasoline used by Ontario commercial vehicles is 69,364,000 gallons. Commercial cars are not included in this discussion, so we should deduct their consumption from the total, 262,733,000 gallons. Then all passenger cars, Ontario and foreign, use 262,733,000 - 69,364,000 = 193,369,000 gallons. Since 9% of all passenger car traffic is foreign cars buying gasoline, then foreign passenger cars would consume 193,369,000 x .09 = 17,400,000 gallons.

This is somewhat higher than the 13,400,000 which we allowed, but it is quite possible that more than 1/4 of the cars bought their gasoline in the States. These were prohibition days in the States and short trips into Canada at all seasons were probably more common then (1932) than today.

The result of our analysis would not have been materially changed if 17,400,000 gallons had been allowed instead of 13,400,000 gallons.

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Amplification of second paragraph.

Explanation of Method for Deriving
Cost Increments in Col. (10) Table III

The highway cost indices in Col. (8) represent the relative total cost of facilities required for each class. What we wish to find, however, is the difference in the cost of facilities required for each class; that is, the increment of annual cost which each class requires in addition to that required by the next lighter class.

In order to obtain these increments, we first find the differences in cost index (Col.8) between classes and tabulate these differences in Col. (9). The sum of these differences is equal to 1.93, the index for the heaviest class, since the sum of all differences should equal the whole.

In order to obtain the actual increments of annual cost (Col. 10) required by the several classes, the total annual cost ($50,721,000) is allocated to the several classes in proportion to the increments of cost index (Col.9). The details of this allocation are shown below.

Class X requires the entire cost corresponding to index 1.93. Classes I and II have an index of 1.00, so their share of the cost is $\frac{1.00}{1.93}$ of $50,721,000 = $26,280,000. The index for Class III is 1.15, so they require .15 more units of cost index than Classes I and II, and their increment of cost

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is $\frac{.15}{1.93}$ x $50,721,000 = $3,942,000. The Class IV index is 1.30, so its increment of index over Class III is 1.30 - 1.15 = .15 and its increment of cost is $\frac{.15}{1.93}$ x $50,721,000 = $3,942,000. The same procedure is repeated for each heavier class until the entire $50,721,000 has been distributed as in Col. (10).

It should be pointed out again that the total cost of facilities for any particular class is equal to its increment plus all of the increments required by all lighter classes.

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Effect of high taxes on trucks.

We have stated that the high charges derived in this study might have the effect of driving heavier classes of vehicles off the road because they could not operate at a profit. This is not necessarily so if the higher charges are passed on to the shippers.

Net Profit = Gross Revenue - (Operating Cost plus Taxes).

An increase in taxes will reduce the profit only if the gross revenue is not correspondingly increased. If the rates charged to shippers are increased to cover additional taxes, a net profit is still possible.

The transport service furnished by trucks is superior in many respects to that furnished by other transportation agencies and consequently is entitled to relatively higher rates.

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There is no reason why an industry should not pay the full cost of highway transport; it should not thrive on subsidies paid by either the general public or the passenger car owner.

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Table III is a distribution of costs on basis of facilities required and shows that the annual cost of the facilities required for the passenger car is about one-half the total annual cost of highways.

The straight ton-mile basis of allocation of cost puts upon Classes I and II about $14,000,000 per year more than the annual cost of the facilities these two classes require.

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Weighted Annual Mileages

There is little data with reference to Ontario highways, and in fact not much dependable data available in the States, which give dependable mileage values for different classifications of trucks. There are, however, several sources giving average annual mileages of commercial vehicles. From the data available for different classifications of vehicles and from our experience in similar studies, we have assumed certain average annual mileages for each classification. The following is a reconciliation of those assumptions with the recorded values for average annual mileages for commercial vehicles given in various reports of the U.S. Bureau of Public Roads.

Using the mileages given in our Table IV, we have computed the weighted annual mileage of trucks and busses with the following results;- the average for trucks is 10,100 miles, for busses it is 27,600 miles. These average figures for trucks compare favorably with similar average mileages for Wisconsin 9,000 miles, Illinois 9,000 miles, Michigan 10,000 miles, New Hampshire 8,000 miles, and Minnesota 9,400 miles ("Public Roads", April 1933; May 1933; June 1933; April 1936; March 1936).

The mileages which have just been quoted are mostly related to traffic in the year 1932, which was in the depth of the depression. They would be considerably greater at the present time.

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Mileages Assumed within Classes

The estimates we have used were based largely upon available information in the States, there being very little information available in Ontario. From these data the average mileage applicable to each weight class was written down and then the average of all such data taken. These results indicated that truck mileages increased about 2000 miles for each ton increase in gross weight starting with 10,000 miles for the delivery truck in Class II (5000 lb. gross weight).

Empirical formulas suggested by U.S. Bureau of Public Roads were also studied, and showed about the same results as obtained above, so we adopted the schedule of mileages shown in Tables IV and V which increase 2000 miles per class for commercial trucks.

Farm trucks were arbitrarily assigned lower mileages; 4000 for Class I, and 5000 for Classes II and III, on account of their seasonal and local use.

Municipal trucks were also assigned lower mileages arbitrarily - 10,000 miles. These probably do not get as intensive use as commercial vehicles.

Busses

All available data definitely points to higher mileages for busses than for trucks, particularly the larger busses. The lighter busses are probably school and hotel busses. We

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assigned busses in Class II, 12000 and increased mileage by steps of 2000 to Class IV, and then by steps of 4000 miles to a maximum of 40,000 for Class X. There is plenty of evidence that the large busses have even higher mileages.

Trailers

There are a large number of trailers in Class I which weigh under 1 ton gross. These must be two-wheel trailers hauled behind autos - such as those carrying milk, cheese, camping outfits, etc. They probably do not cover many miles. We have given them 3000 miles.

The trailers in Class II (1 to 2 tons) may be house trailers or large trailers of the same kind as in Class I. We have given these 4000 miles.

Trailers in Class III are still too small to be commercial. We have been told that they carry onions. We have given them 5000 miles. The trailers in Class IV are much of the same character; these we have assigned 8000 miles, substantially less than for trucks of the same class (14,000).

For Classes V to X, the trailers are assigned the same mileage as trucks. It is a question whether trailers make the same mileage as single trucks, but the trailers are probably attached to those trucks or tractors which do better than the average mileage for their group, so that a mileage for

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trailers equal to that of the average for the group may compensate for the trailer lay-offs for loading purposes.

Gas Consumption

Rates of gasoline consumption were based principally on data in "Taxation of Motor Vehicles - 1932", p. 268, Table 240, "Bureau of Public Roads". See following page showing rates of consumption corrected into Imperial gallons and adjusted to fit Ontario weight classes used in our report.

The total gasoline used by all vehicles (262,733,000 gallons) was obtained by dividing the revenue from gasoline tax in 1936 by the tax rate of $.06. Since we did this, however, the Bureau of Statistics (Dominion) has published a figure of 260,721,000 gallons for net gasoline sales in Ontario in 1936. This figure appeared too late for us to adopt; the difference is but 1% and if the new figure were adopted it would require a slight adjustment in mileages and probably have a negligible effect upon the resulting charges.

Estimates of Gasoline Consumption

Class	Gross Weight (Pounds)	General Motors Truck Co. Miles per Gal. U. S.	General Motors Truck Co. Miles per Gal. Imperial	Warner Tufts Formula Miles per gal. U. S.	Warner Tufts Formula Miles per gal. Imperial	U.S. Bureau of Public Roads Miles per gal. U. S.	U.S. Bureau of Public Roads Miles per gal. Imperial	Amounts assumed in C. B. Breed Ontario Report M. P.	Amounts assumed in C. B. Breed Ontario Report Imp. Gal
I	4,000	13.0	15.6	12.8	15.4	13.0	15.6		16.0
II	5,000	11.7	14.0	10.3	12.8	10.7	12.9		14.0
III	7,000	10.2	12.2	8.3	10.0	8.9	10.7		12.0
IV	9,000	9.1	10.9	6.9	8.4	7.5	9.0		10.0
V	11,000	8.2	9.9	6.1	7.3	6.7	8.1		9.0
VI	13,000	7.6	9.1	5.4	6.5	6.0	7.2		8.0
VII	15,000	6.8	8.2	4.9	5.9	5.5	6.6		7.5
VIII	17,000	6.3	7.6	4.5	5.4	5.1	6.1		7.0
IX	19,000	5.8	7.0	4.2	5.1	4.8	5.8		6.5
X	21,000 (23,000	5.5 5.2	6.6 6.2	3.9 3.7	4.7 4.5	4.5 4.3	5.4 5.2		6.0 6.0

By interpolation from Table 241, "Taxation of Motor Vehicles in 1932",

U.S. Bureau of Public Roads

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Pay load is taken as 55% of the maximum licensed pay load.

Weight measurements supporting 55% pay load were obtained by Ontario Highway Department at Welcome Scales on Highway No. 2, November 23-29, 1937 and at Dundas Forks Scales, Highway No. 5, November 23-29, 1937.

These results are contained in bound volume of Answers to Questionnaire filed by Ontario Highway Department.

Empty weights were estimated based on data in Tables 229 to 232 in "Taxation of Motor Vehicles in 1932", U. S. Bureau of Public Roads.

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The following is a table illustrating the method of computing the the varying rate of charge per ton-mile developed in Col. (13), Table V.

Portion of Annual Cost contributed by Classes I and II by the "Square Root of Wheel Load" method, $24,987,000, is used here as a basis for the Ton-Mile Rate for Classes I and II as follows:

$$\frac{24,987,000}{6,169,421,000} = 0.0040501$$

The ton-mile rate is increased by a uniform amount between classes which we will call x. The rate for Class III is .0040501 plus x, for Class IV, .0040501 plus 2x and so on as tabulated below.

Class	Gross Ton-Miles	Rate	K Gross Ton-Miles ×.0040501	K' Gross Ton-Miles × the x term in the rate
I & II	6,169,421,000	0.0040501	$24,986,772	$ 0
III	235,169,000	0.0040501 + x	952,458	235,169,000 x
IV	275,788,000	" + 2x	1,116,969	551,766,000 x
V	248,708,000	" + 3x	1,007,292	746,124,000 x
VI	294,231,000	" + 4x	1,191,665	1,176,924,000 x
VII	623,150,000	" + 5x	2,523,820	3,115,750,000 x
VIII	145,996,000	" + 6x	591,298	875,796,000 x
IX	284,252,000	" + 7x	1,151,249	1,989,764,000 x
X	100,568,000	" + 8x	407,310	804,544,000 x
	8,377,283,000		$ 33,928,833	$ 9,495,837,000

Total amount to be allocated ($50,721,000) equals sums of the K terms plus the sum of the K' terms, i.e.,

$$50,721,000 = 33,928,833 + 9,495,837,000 x$$
$$16,792,167 = 9,495,837,000 x$$
$$0.00176837 = x$$

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Rates Used in Col. (13) of Table V.

Class	Increasing Rate 0.0040501 + x + 2x etc.
I & II	0.0040501
III	0.0058185
IV	.0075868
V	.0093552
VI	.0111236
VII	.0128919
VIII	.0146603
IX	.0164287
X	.0181971

Example:-

Class V Rate = .0040501 + 3 x

= .0040501 + .0053051

= .0093552

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The proposed charges per vehicle are not inconsistant with those published in Legislative Document (1938) No. 41 State of New York, "Report of the Joint Legislative Committee on State Fiscal Policies". Motor Vehicle taxes are treated on pages 209-220 and tables are given showing rates charged for different motor vehicle classifications in different states of the union.

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The note on the figure which reads "11' lanes easier to maintain" means that if the lanes are 11' wide the wide trucks do not run off the edge of the pavement and cause heavy shoulder maintenance as they do when the lanes are narrow.

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Traffic on Important Routes in Ontario

Average Day for 1936 estimated from Summer, Fall and Winter Counts in 1932.

Route 2, between Toronto and Hamilton near Long Branch (6-lanes divided)	10,000 per day
Route 3, east of Windsor near Maidstone (2-lanes being widened to 4-lanes divided)	2,600 " "
Route 11, north of Toronto near Richmond Hill (3-lanes)	9,000 " "

NOTE: Summer average day would be about 50% higher.

The quotation on this page comes from p. 135 of "Public Roads", Sept. 1937.

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A 3-lane pavement widened to 4-lanes at summits was observed on Route 11, north of Toronto between Richmond Hill and Aurora.

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While Fig. 16 is a theoretical exposition of traffic on a given road in that all vehicles are relatively uniformly spaced, nevertheless it is a thoroughly practical picture of what happens on this particular highway which is a typical highway. When, for example, the vehicles are not uniformly spaced, a large number of the smaller vehicles become bunched behind one heavy truck and less behind another than are showing in the illustration of Fig. 16.

Had this figure been carried further to the right, the diagram would present even worse conditions because that condition in the right half of the diagram would be constantly repeated.

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Hazards Caused by Big Trucks.

See Missouri Report, pp. 128-134.

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Saving in Operating Cost for Passenger Cars and Trucks

Dean T. R. AGG, Iowa State College, has stated in "Civil Engineering", December 1932, page 762, that a passenger car saves .8¢ and trucks 5¢ per mile when a pavement is improved from an intermediate stage to a high type. This article was written in 1932; the savings he mentioned are probably higher than they would be today.

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Effect of Grades in Motor Truck Speeds

In the Lincoln Tunnel under the Hudson River in New York, trucks of greater than 5 tons gross weight and trucks which cannot maintain a speed of at least 20 miles per hour on the exit grade (3 1/2%) will not be allowed to operate, while the tunnel is operating on a one-tube basis, i.e., with only one lane for each direction of travel.

See Engineering News-Record, November 18, 1937.

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Fig. 17 is based upon the mileages used in Tables IV and V of this report. In individual cases they run much higher for the heavy trucks.

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Summary

In simple terms our report has done the following:

(1) It determines the annual cost of highways and examines the problem by the application of the public utility principle.

(2) It gives to the motor vehicle all the roads outside cities and all streets within cities that existed at the beginning of 1919.

(3) It recognizes that from 1919 to date motor vehicles have paid only about one-half the annual cost of rural highways and city streets, and places upon the public the large highway deficit that has thereby accumulated during the past 18 years, but it takes the position that from now on motor vehicle users should pay the full annual cost of highways and streets because for at least two generations, the general public will be paying $14,000,000 a year for amortizing the highway debt that already has accumulated since 1918.